

ELECTRON-PHONON INTERACTION AND HIGH T_c

The news story "High T_c May Not Need Phonons; Supercurrents Increase" by Anil Khurana (July 1987, page 17) mentioned Morrel Cohen's suggestion on possible experiments for understanding whether high- T_c superconductors are phonon mediated. Cohen pointed out that once the isotope effect experiments can be repeated on $\text{La}_{2-x}(\text{Ba,Sr})_x\text{CuO}_{4-y}$ with various concentrations of barium or strontium, one may be able to observe an isotope effect for some concentrations, provided that the superconductivity is mediated by phonons and the Coulomb repulsion is not affected by doping. It is not necessary in my opinion to assume that Coulomb repulsion is not affected by doping in order to observe an isotope effect. If the mechanism of superconductivity in these high- T_c superconductors is similar to that in the strong-coupling transition metal superconductors, Coulomb repulsion may be modified to break the conditions of nullifying the isotope effect. In fact I think it is more likely that varying the doping concentrations would modify the Coulomb repulsion rather than the phonon attraction. This is because changing doping concentrations primarily modifies the electronic properties. Since the phonons that are most likely to have contributions to the superconductivity are those associated with the Cu-O bondings, the modification of x in $\text{La}_{2-x}(\text{Ba,Sr})_x\text{CuO}_{4-y}$ may not have too much to do with changing the phonon attraction.

NAI-CHANG YEH

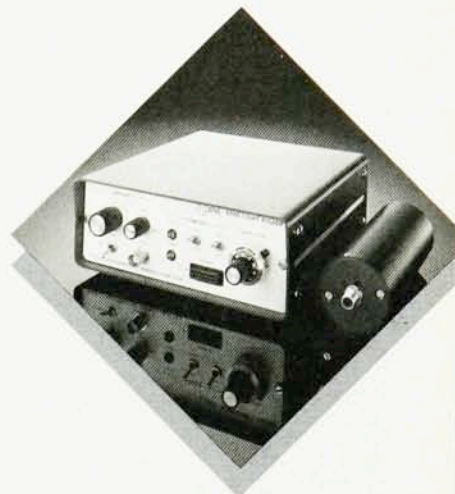
Massachusetts Institute of Technology
8/87 Cambridge, Massachusetts

I wish to point out an omission and a misleading statement in an otherwise excellent discussion on high- T_c superconductors by Anil Khurana in the July 1987 Search and Discovery section. In giving a brief history of the isotope effect he correctly states that Pierre Morel and Philip Anderson in 1962 and James W. Garland in 1963 "showed that a reduced—and even a

vanishing—isotope effect is possible within the BCS theory for phonon-mediated superconductivity." The omission in the article is the fact that I stated in 1959 (*Phys. Rev.* **116**, 45) for the first time that the isotope effect would be reduced by the Coulomb interaction. The 1962 Morel and Anderson paper refers to my paper. In Anderson's recent invited talk at the APS New York March meeting, entitled "It's Not Over 'til the Fat Lady Sings," he graciously acknowledges this 1959 work. My 1959 paper was followed by another in 1962 (*IBM Journal* **6**, 14; that issue was essentially the proceedings of the June 1961 IBM Conference on Superconductivity), in which I stated, "In fact, according to our model, there is no reason why ξ [the parameter giving the size of the deviation of the exponent from $1/2$ and determined in the theory by the relative strengths of the Coulomb and electron-phonon interactions] cannot be larger than one, leading to a positive exponent in the isotope effect." Since the theory gives a continuous variation from negative to positive exponents, by implication there are points for which the isotope effect vanishes even though the electron-phonon interaction produces the superconductivity. This second paper of mine was submitted 15 September 1961, almost one month before the Morel-Anderson submission. Although Morel and Anderson treated more actual metals than I did, they did not bring up the possibility of a zero or negative isotope effect with the electron-phonon interaction. Garland, who further advanced the theory in his 1963 paper, referred to my earlier IBM paper.

In 1967, reporting on the positive superconducting isotope effect found in alpha-uranium (from which some prominent physicists concluded incorrectly that some mechanism other than the electron-phonon interaction was responsible for the superconductivity), Gloria Lubkin (*PHYSICS TODAY*, December 1967, page 60) pointed out that I and Garland had earlier sug-

**The ideal way
to stabilize PMT
systems and
calibrate
phototubes.**



**Use the new
BNC Light Pulser.**

Now it's a simple matter to calibrate and check out photomultiplier tubes and other light detecting systems. The BNC Model 6000 Light Pulser, with either a 490 or 568 nm optical source (as shown), generates stabilized pulses of light. It's ideally suited for measuring drift and temperature effects, and can be part of a gain stabilizing system.

Light pulses are stabilized for both power output and color. The output is monitored and corrected to maintain a constant energy, and the LED source is thermoelectrically-cooled.

This state-of-the-art instrument can also be used with a variety of programmable instruments, such as amplifiers and power supplies, to form the basis of a stabilizing system. Call John Yee at BNC for more details.



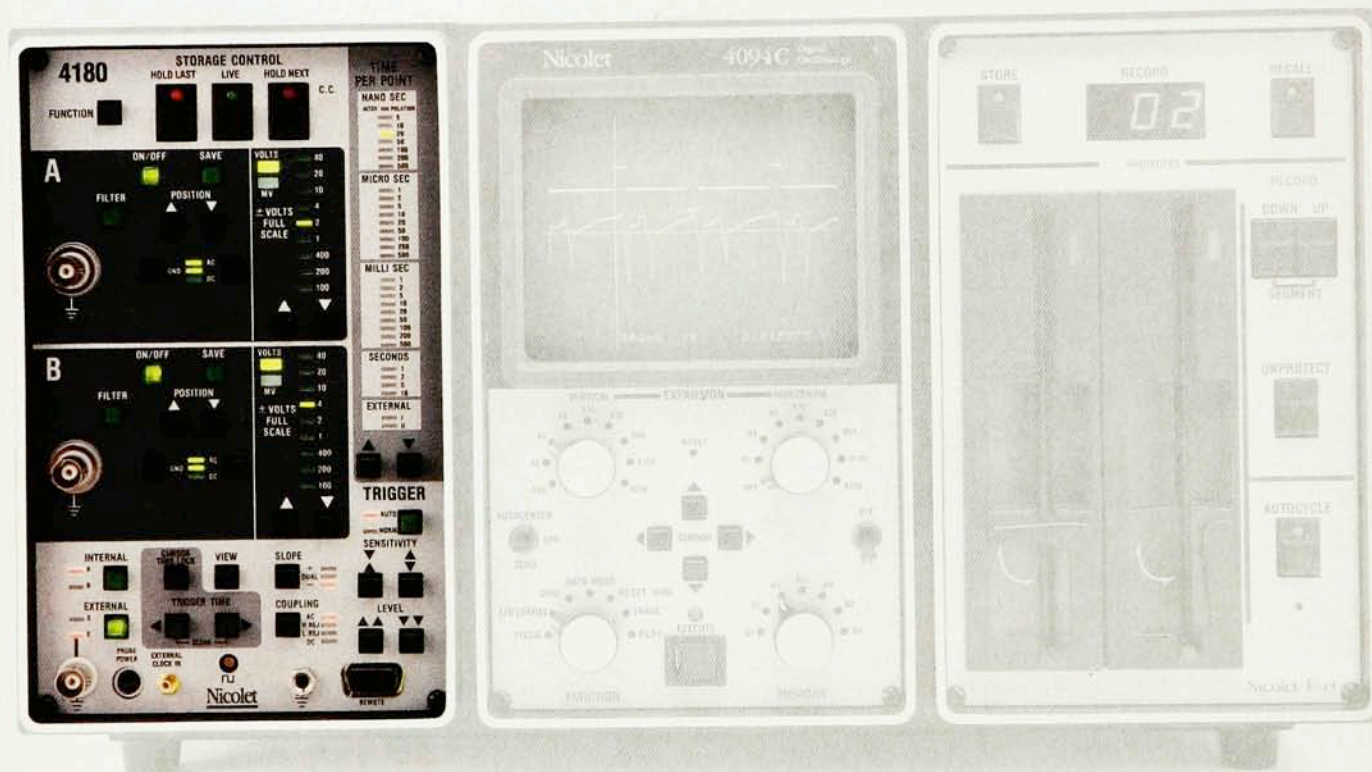
Berkeley Nucleonics Corp.

1121 Regatta Square
Richmond, CA 94804
(415) 234-1100

Circle number 9 on Reader Service Card

The New 4180 Plug-In

SPEED TRIALS.



- *Multi-channel: two or four channel configurations.*
- *Unmatched single-shot capabilities.*
- *High speed, 200 MHz digitizing.*
- *100 MHz analog input bandwidth.*
- *Real-time math functions.*
- *For your Free Speed Trial call: 800-356-3090 or 608-273-5008*

Nicolet Digital Oscilloscopes

Speed. Using the latest designs in ADC technology, your input signal can be digitized at speeds up to 200 MHz (5ns per data point) and saved for analysis. The wide band input amplifiers allow signals up to the 100 MHz Nyquist limit to be input without distortion. Sophisticated trigger setup displays allow you to accurately set the level, sensitivity, and slope to make one-shot transients easy to catch; eliminating the usual hit or miss guesswork. For multi-channel applications two 4180's can operate together in one mainframe producing a four channel scope with no degradation in speed or performance.

Real-Time Math. In addition to the extensive post-processing capabilities in the mainframe, the 4180 has several useful routines which present computed results as live, real-time displays: *FFT, MAX/MIN, A+B, A-B, A×B, A/B, and AVERAGING.*



Nicolet Test Instruments Division
P.O. Box 4288
5225-2 Verona Road
Madison, WI 53711-0288

Nicolet
INSTRUMENTS OF DISCOVERY

Circle number 10 on Reader Service Card

gested the possibility of a positive isotope effect with the electron-phonon interaction.

It is not surprising that the present Search and Discovery report does not acknowledge my earlier work, since it is not referred to in either of the June 1987 *Physical Review Letters* articles reporting on the zero isotope effect in Y-Ba-Cu-O. Marvin Cohen (a co-author of one of the articles) did, however, in his summarizing remarks at the June 1987 Berkeley Conference on Novel Mechanisms in Superconductivity, refer to my work.

This brings me to the second point I want to make concerning the 1987 Search and Discovery report. I believe the statement that the discovery of the isotope effect in 1950 "provided the first hint of the importance of phonons in the formation of the superconducting state" is misleading. Actually, Herbert Fröhlich proposed the electron-phonon mechanism for superconductivity before the results of the isotope experiments were known, at least to him. In his famous 1950 *Physical Review* article, he has a note added in proof that he had just learned about the isotope effect results and that they were consistent with his proposed mechanism. I remember well as a graduate student at Purdue in the winter of 1949-50 how Fröhlich would talk at length about superconductivity in his statistical mechanics class (much to the consternation of some of the graduate students who were more interested in learning what they thought they needed to pass the preliminary exam).

JAMES C. SWIHART
Indiana University
Bloomington, Indiana

8/87

KHURANA REPLIES: I thank James Swihart for stating so clearly that Herbert Fröhlich had proposed, even before the isotope effect experiments were done, a mechanism for superconductivity based on electron-phonon interactions. In my news story, I wished merely to point out the importance of the isotope effect experiments; I could not discuss in detail the various steps in the development of the theory of superconductivity. As for the omission: Unfortunately, not only did the reports of isotope effect experiments on the 90-K materials not mention Swihart's contribution, but a review article I consulted did not refer to his 1959 paper.

The discovery of new high-temperature superconductors has created a

tremendous resurgence of interest in superconductivity. It is generally accepted that superconductivity arises from Bose condensation of electron pairs that are effectively bound together. It is not widely realized that this suggestion was first made by Richard A. Ogg Jr in the mid-1940s.¹ According to John M. Blatt, Ogg was outside the tradition of solid-state physics and his suggestion was strongly discounted and was not taken up by theorists to develop a theory of superconductivity.² Later, the BCS and related theories were developed. These theories use the idea that electron-phonon interactions may cause electrons to become effectively bound in pairs. It seems clear that BCS-like theories were developed without conscious borrowing from Ogg's ideas, and these theories go far beyond Ogg's suggestion. It is equally clear, however, that Ogg has priority for the electron pair-Bose condensation idea, and this should be recognized. One way would be to use the term "Ogg pairs" to mean any electron pairing scheme leading to superconductivity through Bose condensation. The term "Cooper pair" (or preferably "Ogg-Cooper pair") could be reserved to denote specifically pairing arising from electron-phonon interactions.

References

1. R. A. Ogg Jr, *Phys. Rev.* **69**, 243 (1946).
2. J. M. Blatt, *Theory of Superconductivity*, Academic, New York (1964), pp. 86-88.

ALAN L. ROCKWOOD
University of Delaware
Newark, Delaware

8/87

Mendel and the SSC: Two p's in a Pod

Our traditions provide different models of progress. On the one hand, the "great American genius syndrome" encourages one to seek technological progress in the work of isolated genius. The conflicting virtue of "thriving American free enterprise," which harnesses organizational skills to create progress, seems to better fit World War II Liberty Ships than it does our concept of scientific progress. Even though my training denies the myth, I still find it unsettling to argue for a \$4 billion SSC project, which expects scientific progress from a planned group effort rather than individual genius.

During a vacation visit to Brno, Czechoslovakia, I was afforded the opportunity to visit the Mende-

AMERICAN MAGNETICS, INC.



Excellence In Superconducting Magnets

*Cryogenic Instruments
And Accessories*

- ★ Superconducting Magnets
- ★ Dewars
- ★ Power Supplies
- ★ Energy Absorbers
- ★ Power Supply Programmers
 - Manual
 - IEEE-488 or RS-232C
- ★ Helium Level Meters
- ★ Helium Level Sensors
- ★ Nitrogen Level Meters
- ★ Nitrogen Level Sensors
- ★ Magnet Support Stands
- ★ Vapor Cooled Current Leads
- ★ Complete Magnet Systems

AMI has been designing and manufacturing superconducting magnets and cryogenic instrumentation for over 18 years. Our focus is on quality, innovation, excellence, service and customer satisfaction. The professional staff at AMI will assist you in designing and building a custom integrated system. Our commitment to excellence has made AMI the leading U.S. manufacturer of laboratory superconducting magnet systems.

Call or Write:

AMERICAN MAGNETICS, INC.
P.O. Box 2509
Oak Ridge, TN 37831-2509
Telephone (615) 482-1056
Telex 557 592

Circle Number 11 On Reader Service Card
For Free Product Catalog
APS SHOW-Booth #211